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CHEMICALS AND METHODS USED IN TREATMENTS OF TREES BY INJECTIONS, WITH ANNOTATED BIBLIOGRAPHY

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The injection of chemicals into trees and growing plants has been of interest for many years. Some of the earliest records date back to the early part of the seventeenth century. Craighead and St. George (24) have recently published a review of the work that has been done by the United States Department of Agriculture on the control of forest insects by this means, and they include a historical résumé of the early work in the field.

Many methods of introducing chemicals into trees have been proposed and several have been patented. They are all based on the idea of introducing chemicals into the sap stream of the living plant, to be distributed throughout the plant by the circulation of the sap.

The objectives of these treatments are varied and include (1) the tracing of the course of the sap stream by colored solutions, (2) the coloring of the wood for special purposes, (3) the preservation of the wood from decay, (4) the treatment of diseases resulting from the deficiency of certain chemicals, (5) the poisoning of undesirable tree species, (6) stimulation and fertilization by nutrient solutions, (7) the control of fungous organisms and diseases, and (8) the control of insects attacking the plants.

In cases where tree injections are practiced with the idea only of introducing a preservative into the wood, saving the life of the tree is of minor importance. Attempts to kill insects attacking living trees by means of the introduction of chemicals into the sap stream and without harming the host have not been uniformly successful. Craighead and St. George (24) state that to their knowledge no practical method of killing the parasite without harming the host has been developed. The successful control of insects attacking trees by injection of chemicals has, however, been reported by several other investigators. Others have reported very favorable results from the injection of nutrient and fertilizing solutions into trees, without harmful effects. Beneficial effects from the injections of antiseptic and fungicidal compounds have also been reported as well as the curing of mineral deficiency diseases, such as chlorosis, by the injection of solutions containing the missing element.

Consideration of the list of chemicals that have been used in this kind of work reveals the fact that a systematic investigation of the different classes of chemical compounds has not been made. It should appear

possible to find, among all the compounds available, certain ones that could be injected into trees without harmful effects, and which would render them toxic or repellent to insects and fungous organisms. The chemical and physiological principles are apparently sound, and the increased application of tree injections awaits only the discovery of the right compounds for the particular purposes desired.

There is presented herewith, for the information of those interested, an annotated bibliography of the references in the literature on the subject of tree injection and medication with chemicals. The references are arranged alphabetically, and the list is intended to be complete up to January 31, 1938. A list of United States patents relating to injections into trees is also included.

Anonymous (1)

1709. Sur la circulation de la seve dans les plantes. Hist. Acad. Roy. Sci. 1709:44-49. (Cited by J. Sachs, Geschichte der Botanik, p. 508. 1875. (Munich.)

Magnol introduced colored solutions into plants in order to find through what channels the sap passed.

Anonymous (2)

1927-28 Inoculation of trees for scale tried in South Africa. Calif. Citrograph 13-14:439.

Reference is made to a recent issue (not specified which) of The South African Citrus Grower in which a process of injection with a serum is recommended for the control of scale insects on citrus trees. The question is raised as to the efficacy of this treatment.

Anonymous (3)

1935. Injection of fertilizers into fruit trees, research in progress at East Malling. Chem. Age (London) 32:528.

Reference is made to the annual report for the 22nd year of the East Malling Research Station under the auspices of the Kent Incorporated Society for Promoting Experiments in Horticulture. The invigoration of trees by the injection of fertilizers as an alternative to applying them to the soil was one of the new developments. The cure of chlorosis in a peach tree by injections of iron sulphate is also mentioned.

Anonymous (4)

1937. Beetles in trees controlled by poison carried in sap stream by new method. DuPont Agr. News Letter 5:11-12. Excerpts, Canad. Ent. 69:23.

An abstract of information in the article "Experimental work with tree medication" which F. C. Craighead and R. A. St. George presented at 8th annual meeting of the Eastern Branch of the American Association of Economic Entomologists. Zinc chloride and copper sulphate are mentioned.

Bedard, W. D. (5)

1938. Control of mountain pine beetles by means of chemicals. Jour. Forestry, 36:35-40.

The article describes experiments for the control of mountain pine beetles by the introduction of chemicals into trees by injections. The materials used included sodium arsenite, zinc chloride, sodium fluoride, copper sulphate, potassium cyanide, sodium arsenate, sodium fluosilicate, mercuric chloride, ammonium fluoride, sodium thiocyanate. All but copper sulphate, sodium arsenate, and zinc chloride have been discarded because of their ineffectiveness or their extreme toxicity and consequent danger in use.

Bennett, J. P. (6)

1931 The treatment of lime-induced chlorosis with iron salts. Univ. of Calif. Agr. Expt. Sta. Circ. 321, 12 pp.

Dry salts as well as solutions were injected into trees for the temporary cure of chlorosis. Any soluble iron salt may be used for this purpose. Mention is made of iron sulphate, iron chloride, iron nitrate, ferrous or ferric citrate or tartrate, and iron ammonium tartrate. Holes were bored into the tree trunk and the materials were put in dry and also in solution.

Blin, H. (7)

1935. La régéneration des arbres fruitiers par la nutrition artificielle. La Nature, 63 (1): 304-6, illus.

Injections of nutrient solutions were made into fruit trees with very good results.

Blinks, L. R. (8)

1928. The injection of sulfates into valonia. Jour Gen. Physiol. 12: 207-8.

Potassium chloride and sulphate were injected into the cells of Valonia (a species of oak). The surviving cells tolerated the presence of these solutions.

Bolley, H. L. (9)

1903. Tree feeding and tree medication. N. Dak. Agr. Expt. Sta. (14th) Ann. Rept., pp. 55-58.

Mention is made of the injection of solutions of chemicals into apple trees and cottonwood trees, but no data are given as to the compounds used.

Bolley, H. L. (10)

1904. Experiments on internal tree feeding and medication. N. Dak. Agr. Expt. Sta. Ann. Rept., p. 56.

A brief statement is made concerning the work on tree medication but no details are given.

Bonnet, Charles (11)

1754. Recherches sur l'usage de feuilles dans les plants, et sur quelques autres. Sujects relatifs a l'histoire de la végétation. 343 pp. illus.

Boucherie, A. (12)

1840. Memoire sur la conservation des bois. Ann. Chim. et Phys. 74:113-157.

In injection experiments the author used an 8-percent solution of crude pyrolignite of iron, a 15-percent solution of calcium and sodium chloride, an alcoholic solution of sodium sulphate and rosin, iron sulphate, mercuric chloride, arsenic acid, sulphuric acid, copper sulphate, and zinc sulphate for the preservation of wood against decomposition.

Boucherie, A. (13)

1841. Nouvelles recherches sur la conservation des bois. Compt. Rend. Acad. Sci. [Paris] 12:337-339.

A continuation of the work on the injection of chemicals into trees by means of holes and saw cuts.

Brooks, F. T., and Bailey, M. A. (14)

1920. Silver leaf disease (including observations upon the injections of trees with antiseptics). Jour. Pomol. 1(2):81-103.

Iron sulphate, artificial manures, salicylic acid, neo-salvarsan, eosin, methyl violet, congo red, gentian violet, and methylene blue, were injected into tree through the roots. Corrosive sublimate, quinine sulphate, and sodium arsenate were also tried.

Buffon, G. L. L. (15)

1755. Histoire naturelle des arbres.

Bull, Henry, and Chapman, R. A. (16)

1935. Killing undesirable hardwoods in Southern forests. U. S. Dept. Agr. Forest Serv. Occas. Paper 50, 19 pp., bibliog.

The most effective method of poisoning is to swab or pour the poison into a complete girdle or frill around the tree. In general arsenicals have been more widely used. Among other substances that have been found effective in killing trees and shrubs, the following may be mentioned as representative: Sodium and calcium chlorates, potassium chromate and bichromate, copper and iron sulphates, copper, sodium, barium, and zinc chlorides, ammonium thiocyanate, formaldehyde, carbolic acid, sodium fluoride, ethylene oxide, cresylic acid, kerosene, and creosote. Different investigations in which the same poison was used have frequently given different results. It is very difficult to draw specific conclusions.

Calvino, M. (17)

1919. Intra organic injections for the purpose of increasing the yield of plants, experiments in Mexico and Cuba. Rev. Com. y Trab. [Cuba] 2:287-291. Havana.

Old pear trees were revised and made to bear fruit by injections of nutrient solutions.

Coffignies, J. (18)

1910. L'emploi du sulfate de fer pour combattre la chlorose des arbres fruitiers. Rev. Hort. [Paris] 82:496-497.

Fruit trees were injected with iron sulphate in the control of fungus diseases such as chlorosis.

Collison, R. C., Harlan, J. D., and Sweeney, M. P. (19)

1932. Direct tree injection in the study of tree nutrition problems. N. Y. State Agr. Expt. Sta. Tech. Bull. 192,36pp., bibliog.

The purpose of these injections was to supply nutrients to the trees by direct injection. The materials included potassium nitrate, sodium nitrate, calcium nitrate, magnesium nitrate, urea, ammonium sulphate, potassium nitrate plus potassium di-hydrogen phosphate, magnesium nitrate plus sugar, and potassium di-hydrogen phosphate.

Cope, Joshua A., and Spaeth, J. Nelson. (20)

1931. The killing of trees with sodium arsenite. Jour. Forestry 29:775-783.

A sodium arsenite solution injected into the trees through an axe cut, or by a specially designed tool which is described, is recommended.

Cotta, H. (21)

1806. Naturbeobachtungen über die Bewegung und Funktion des Saftes in den Gewächsen, mit vorzüglicher Hinsicht auf Holzpflanzen. 96 pp., illus. Weimar.

Craighead, F. C., and St. George, R. A. (22)

1930 New technique in tree medication for the control of bark beetles. Sci. (N.S.) 72: 433-435.

A method of injection of chemicals into trees is described. The solutions used were wood alcohol, carbon disulphide plus kerosene 50:50, copper sulphate, ethyl monochloroacetate, ethylene dichloride, formaldehyde and water 40 percent solution, hydrocyanic acid in water 5 percent, mercuric chloride solution, potassium cyanide solution, sodium arsenite solution, sodium fluoride solution, zinc chloride.

Craighead, F. C., St. George, R. A., and Wilford, B. H. (23)

1937. A method for preventing insect injury to materials used for posts, poles, and rustic construction. U. S. Dept. Agr. Circ. E-409, 8 pp., illus.

Methods of injection for living trees are described. Recommendations are made for the correct dosages of copper sulphate and zinc chloride for medicating shortleaf pines of various height and diameter classes.

Craighead, F. C., and St. George, R. A. (24)

1938. Experimental work with the introduction of chemicals into the sap stream of trees for the control of insects. Jour. Forestry 36:26-34, bibliog.

A review of the work of the Bureau of Entomology and Plant Quarantine, U. S. Department of Agriculture, on the introduction of chemicals into the sap stream of trees for the purpose of protection against bark beetles and other insects and for preservation of the wood. The chemicals listed as effective for insect control are zinc chloride, copper sulphate, mercuric chloride, zinc metaarsenite, sodium arsenate, sodium arsenite, sodium fluoride, ammonium bifluoride, and ammonium copper arsenite. Also tried but without much success were sodium borate, sodium nitrate, potassium nitrate, pyridine, ethylene dichloride, formaldehyde, ethyl alcohol, methyl alcohol, butyl alcohol, potassium cyanide, hydrocyanic acid, carbon disulphide, and ether. Listed as ineffective are sodium sulphide, potassium dichromate, ethyl mercuric chloride, ethyl mercuric sulphate, chromic acid, picric acid, orthodichlorobenzene, gasoline, kerosene, and creosote.

Deuber, Carl, G. (25)

1929. Theory of tree injections. Proc. Ann. Meeting 5th Nat'l. Shade Tree Conf., pp. 37-38.

The author discusses the work of various experimenters in this field. He points out that this is an extremely difficult field of research but that there is a possibility of the control of certain plant and insect parasites.

Dezeani, S. (26)

1913. Sul comportamento dell' acido cianidrico iniettato nelle piante. Arch. Farmacol. Sper. e Sci. Aff. 16:539-546.

This is a study of the effect of cyanides when introduced into plants.

Elliot, J. A. (27)

1917. The conduction of cyanide of potassium in plants. Phytopathology 7:443-449.

Experiments were conducted for the purpose of ascertaining the path of conduction of potassium cyanide in plants, both herbaceous and woody. Tests for cyanide were made by ferric chloride, and ferrous sulphate solution. The injury to the plants exactly corresponded to the distribution of the potassium cyanide.

Flint, W. P. (28)

1915. The effects of cyanide on the locust borer and the locust tree. Sci. n.s. 41:726-727.

The author injected a 98-percent-pure potassium cyanide and a sodium chloride-sodium carbonate-sodium cyanide mixture containing 35 to 38 percent sodium cyanide into bore holes in locust trees with injury to the trees. No apparent control of the locust borers was noticed. Many trees died, some from the cyanide perhaps, some from borer injury. Many untreated trees died. No chemical tests were made for the presence of cyanide.

Fron, G. (29)

1909. Contribution a l'étude de l'alimentation extraracinaire des arbres fruitiers. Jour. Soc. Natl. Hort. France (Ser. 4) 10:54-59,illus.

Pear trees were treated with solutions of iron sulphate and calcium nitrate. The vigor of the trees appeared to be increased but the improvement was confined to portions of the tree only. The author believed this method to be of little practical value in fruit culture.

Gaudichaud, M. (30)

1841. Note relativement à quelques points de la derniere communication de M. le docteur boucherie sur la vascularites de végétaux. Compt. Rend. Acad. Sci. [Paris] 12:369-372.

The author discusses the work of Boucherie on tree and plant injection.

Gaunersdorfer, J. (31)

1887. Das Verhalten der Pflanzen bei Vergiftungen speziell durch Lithiumsalz. Landw. Vers. Sta. 34:171-206.

Lithium sulphate was injected into plants and trees including small conifers.

Gordon, A. (32)

1925. Injection of chemicals into trees. Calif. Countryman 12:9,22,23.

During the course of investigations of the injections of chemicals into trees by a newly invented method, the author working with Lipman met with success in destroying the aphids on the leaves of certain trees within 24 hours by the use of a certain soluble compound. No mention is made of the compound used.

Magnesium nitrate had a stimulating effect on trees when injected into them.

Gordon, A., and Lipman, C. B. (33)

1926. Further suggestions for the application of the Lipman-Gordon method of tree injection. Sci. n.s. 64:602.

Suggestions are that injections may be valuable for (1) the protection of citrus and similar trees against freezing by injections of electrolytes and non-electrolytes, (2) the stimulation of fruit trees to a much greater fruit-bud production than the normal, and (3) the cure of the chestnut blight.

Graham, R. J. D., and Stewart, L. B. (34)

1927-28, Injection experiments on trees. Bot. Soc. Edinb. Trans. and Proc. 30:19-20.

Solutions of copper sulphate were introduced into trunks of trees (Salix alba, Fagus sylvestris, Ulmus campestris, Acer pseudoplatanus, Tilia europae, and Pyrus malus) about 3 feet above the ground, the course of the solutions being traced by the use of potassium ferro-cyanide.

Hales, Stephen. (35)

1727. Vegetable staticks, or an account of some statical experiments on the sap in vegetables, being an essay toward a natural history of vegetation. 376 pp., illus.

Haring, C. M. (36)

1922. Killing trees and stumps with chemicals. Calif. Agr. Expt. Sta. Rept. 96. Annual Report of the Director.

The author used white arsenic oxide 1 pound, washing soda 1 pound or caustic soda 1/2 pound and 4 gallons of water. Solutions poured into axe cuts made near the base of eucalyptus trees were very effective in killing them.

Hearman, J. Goodman, Levy, B. F., and Roach, W. A. (37)

1936. Tree injection 1935 experiments. East Malling Research Sta. Rept., pp. 137-141, illus., bibliog.

A discussion is given of the injury caused by injections of fertilizer solutions into trees.

Jacobs, H. L. (38)

1928. Injections of shade trees for the control of insects and diseases. Davey Tree Expert Co., Research Dept. Bull 3:1-4. Kent, Ohio. Rev. Appl. Mycol. 8:473.

Two years' experimental work on the injections of chemicals (83 quarts of solutions of 26 unspecified chemicals) into 201 shade trees of 13 species have shown no favorable results except in one case, that of the injection of iron compounds for the cure of lime-induced chlorosis. Most of the chemicals caused severe injury to the trees. Improved apparatus and methods of injection have been developed.

Jacobs, H. L. (39)

1929. The practice of tree injections. Proc. Ann. Meeting 5th Nat'l Shade Tree Conf., pp. 39-42. Rev. Appl. Mycol. 9:501-502.

Numerous powerful germicides and fungicides were injected into chestnut trees in attempts to control chestnut blight and iron deficiency chlorosis. Aniline dyes, gentian violet, acid fuchsin, aloes, strychnine sulphate, nicotine sulphate and arsenic are mentioned. The whole subject of tree injections is discussed.

Kendall, James (40)

1930. Histological and cytological studies of stems of plants injected with certain chemicals (A contribution to the gall problem) 40 pp. illus. Sofia, Bulgaria.

Inaugural dissertation for attainment of doctorate.

Lipman, C. B., and Gordon, A. (41)

1925. Tree injection cure for chlorosis in citrus trees. Proc. 5th Ann. Placer County Fruit Growers Conv., pp. 92-97. Auburn, Calif.

The authors claim that their method of injection of citrus trees with iron salt solutions has been very successful in the cure of chlorosis. Dying and defoliated trees were put into extremely vigorous condition by the treatment. The authors claimed to be able to rid trees of aphids by injections of chemicals, toxic to the aphids, and tolerated by the trees.

Lipman, C. B., and Gordon, A. (42)

1925. Further studies on new methods in the physiology and pathology of plants. Jour. Gen. Physiol. 7:615-623.

The authors discuss the injection of chemicals into trees for various purposes. They used solutions of potassium cyanide, dicyandiamide, sodium nitrate, potassium nitrate, magnesium nitrate, calcium nitrate, potassium dihydrogen phosphate, potassium hydrogen phosphate, magnesium hydrogen phosphate, calcium hydrogen phosphate, calcium chloride, and calcium sulphate.

Lipowitz (43)

1841. Anleitung zur Konservation des Holzes nach Boucherie.

Quoted by Craighead and St. George. The author verified the findings of Boucherie.

MacKinney, A. L., and Korstian, C. F. (44)

1932. The killing of trees with sodium arsenite. Jour. Forestry 30:169-177.

Unmerchantable, undesirable hardwoods were removed from different portions of a partially cut over area by felling, girdling with a V-shaped notch and poisoning by the introduction of sodium arsenite into "frills."

McLarty, H. R. (45)

1936. Tree injections with boron and other materials as a control for drought spot and corky core of apples. Sci. Agr. 16:625-633, bibliog. illus.

Thirty chemicals alone and in various combinations were tested. Significant control of both troubles was obtained with boric acid or manganese borate. No foliage injury was noted with amounts of boric acid up to 5.92 g, although slight injury occurred at the point of injection. Materials used include ammonium carbonate, ammonium nitrate, ammonium phosphate, ammonium tartrate, ammonium sulphate,

calcium citrate, calcium chloride, calcium nitrate, calcium phosphate, calcium sulphate, ferric citrate, ferrous sulphate, potassium carbonate, potassium chloride, potassium citrate, potassium dihydrogen phosphate, potassium hydrogen phosphate, potassium nitrate, potassium permanganate, potassium sulphate, boric acid, manganous borate, magnesium ammonium phosphate, magnesium carbonate, magnesium sulphate, sodium chloride, superphosphate, and zinc sulphate.

McNab, W. R. (46)

1871. Experiments on the transpiration of watery fluids by leaves. Edinb. Bot. Soc. Trans. 11:45-65.

Branches were injected with lithium citrate and the rate of movement measured.

McNab, W. R. (47)

1874-1875. Experiments on the movement of water in plants. Roy. Irish Acad. Trans. 25:343-371, 567-579, illus.

Experiments are described on the injection of lithium, thallium, and caseium solutions into trees to measure the rate of ascent of the liquid.

McWhorter, O. G. (48)

1934. Response of sweet cherry trees to zinc sulfate treatment for little leaf at the Dalles. Oreg. State Hort. Soc. 26th Ann. Rept., pp.56-58.

Holes 1-1/2 inches deep and 3/8 inch in diameter were bored 4 inches apart in the tree trunk just below the ground line and extending slightly downward and around the tree. The holes were then filled with powdered zinc sulphate and plugged with grafting wax. This proved to be an effective treatment of "little leaf" in sweet cherries.

McWhorter, O. T. (49)

1936. Zinc sulfate treatments for little leaf condition of deciduous fruits. Oregon State Hort. Soc. 28th Ann. Rept., pp. 121-124.

The condition is controlled in old trees by boring holes 1-1/2 inches deep and 3/4 inch in diameter about 4 or 5 inches apart around the tree trunk at the ground line and filling with zinc sulphate crystals to within 1/2 inch of the outside.

Mangin, L. (50)

1898. Sur la nutrition et la defense de la vigne par injection. Jour. Agr. Prat. 2:918-920.

The author unfavorably criticized plant injections, especially the idea that grapevines could be protected from fungi by injections. He regarded plant injections as impractical in agriculture.

Messenger, C. B. (51)

1920. Good fiction, poor horticulture. Calif. Cultivator 55:541.

The author discusses briefly the history of tree injections and the work of C. Rumbold.

Metcalf, M. M. (52)

1918. Poisoning tree parasites with potassium cyanide. Sci. (n.s.) 47:344-345.

Injected chemically pure potassium cyanide through bore holes and reported that it did not injure pear and apple trees. All scale insects on these trees died but scale insects on untreated trees also died.

Metzger, R. (53)

1927. Bäume werden gegen Krankheiten geimpft. Die Umschau. 31:666-667, illus.

Protection of trees (elms) against disease is recommended by the injection of the water extract of resistant varieties of trees.

Mokrzecki, S. A. (54)

1903. Ueber die Inner Therapie der Pflanzen. Zeitschr. Pflanzenkrank. 13:259-265, illus.

Experiments on the medication of plants are described. Dry materials as well as solutions were used. Ferrous sulphate, copper sulphate, salicylic acid, potassium cyanide, arsenic salts, and nutrient solutions were used.

Moll, Fredrick. (55)

1915. Die Imprägnierung des Holzes. Chem. Apparatus 2:49-53, illus.

Methods are described for the injection of chemicals into living trees.

Moore, W., and Ruggleo, A. G. (56)

1915. The action of potassium cyanide when introduced into the tissues of a plant. Sci. (n.s.)42:33-36.

Experiments were made on the injection of potassium cyanide into apple trees for the control of borers. The results were not entirely satisfactory.

Müller, A. (57)

1924. Zur inneren Therapie der Pflanzen. Verhandl. Deut. Gesell. Angew. Ent. 4:26-33. (Also Monog. Agnew. Ent. 8:1-26, illus., bibliog.)

The author's investigations endeavored to ascertain the harmless and toxic doses of various chemicals. He stood twigs of lilac in solutions of various chemicals, copper sulphate, sulphuric acid, phenol, and formic acid until the twigs had absorbed not less than 75 percent or more than 100 percent of their own weight. Stems of Vicia faba were cleared of aphids by a solution of pyridine.

The solutions used included sulphuric acid, nitric acid, hydrochloric acid, aluminum sulphate, magnesium sulphate, barium chloride, potassium chloride, sodium chloride, copper sulphate, copper acetate, zinc acetate, mercuric chloride, alcohol, acetic acid, chloral hydrate, phenol, and pyridine.

Müller, A. (58)

1926. Die Inner Therapie der Pflanzen. Monog. Agnew. Ent. 8 (supplement to Zeitschr. Angew. Ent. 12) 206 pp., illus. (Abs. in Rev. Appl. Ent. A.14:505.)

Laboratory experiments were made with aphids, a great number of chemicals being used. Both pyridine and aluminum sulphate caused the wooly apple aphid to leave the treated twigs. Concentrations that proved harmless to plants and those that were injurious are given.

In the field, apple trees and bushes infested with Eriosoma lanigerum were injected by means of bore holes. Injection of 5 percent pyridine cleared the plant. A mixture of equal parts of rhubarb sap, tobacco sap, tomato sap, and an aqueous extract of tobacco plus 1 percent of boric acid had some effect on the infestation. Solutions used contained sulphuric acid, nitric acid, hydrochloric acid, aluminum sulphate, magnesium chloride, barium chloride, potassium chloride, sodium chloride, copper sulphate, copper acetate and ammonia, zinc acetate, mercuric chloride, alcohol, chloral hydrate, formic acid, acetic acid, phenol and pyridine.

Pachassky, I. K. (59)

1903. Enemies of agriculture in the Province of Cherson. Report of the Government Entomologist for 1903. Translation by U.S. Dept. Agr., Forest Serv.

The author reported favorably on the injection of iron sulphate, either as a powder or in solution, in the treatment of diseased fruit trees.

Pearson, G. A. (60)

1937. Poisoning conifers in stand improvement and timber sales practice. Jour. Forestry 35(6)587-590.

The use of sodium arsenite solutions to kill worthless low-grade ponderosa pine trees is described.

Pfeffer, W. (61)

1886. Uber Aufnahme von Anilinfarben in lebende Zellen. Unters. Bot. Inst. Tübingen 2:179-332, illus.

The Physiological action of chemicals on plants is discussed.

Pfitzer, E. (62)

1878. Uber die Geschwindigkeit der Wasserströmung in der Pflanze. Jahrb. Wiss. Bot. 11:177-217.

Salts of thallium were injected into plants and trees and the rate of rise of the solutions measured.

Pierson, H. B. (63)

1927. Control of the bronze birch borer by forest management. Jour. Forestry 25:68-72.

Aloes was injected into bore holes in infested trees but the treatment did not control the bronze birch borer.

Rankin, W. H.

1917. The penetration of foreign substances into trees. Phytopathology 7:5-14.

Injections were made of lithium nitrate solution into chestnut trees. Injections were made by connection between a solution and a hole bored into the tree. Cross sections were taken and analyzed for the spectrum of lithium. The materials penetrated to all sections of the tree where there was active translocation. Complete penetration of heartwood was obtained in trees less than 3 inches in diameter.

Roach, W. A. (65)

1933. Tree injection-- A Progress Report. East Malling Research Sta. 21st Ann. Rept., pp. 137-141.

Simple methods are described for injecting solutions into trees A whole tree can be injected uniformly with a single substance. Each main branch can be injected independently with different materials. In two cases attacks of apple mildew were controlled by injections of sodium thiosulphate.

Roach, W. A. (66)

1934. Injections for the diagnosis and cure of physiological disorders of fruit trees. Ann. App. Biol. 21:333-343., illus., bibliog.

The author summarized in part that "Direct injection of solutions into trees is therefore suggested as an additional method for studying and possibly even curing physiological disorders, especially those of the deficiency type. Methods for injecting whole trees, separate branches with or without their corresponding roots, or separate twigs are described. Some effects of injection on the vigor of the tree and on disease are mentioned."

Experiments are reported on the injection of sodium thiosulphate for the control of apple mildew. The experiments succeeded twice and failed twice.

Experiments are also reported on the injections of nutrient solutions into apple trees.

Roach, W. A. (67)

1934. Tree injection-- invigoration by the injection of fertilizers. Progress report. East Malling Research Sta. 22d Ann. Rept., pp.135-138.

Cox's orange pippin apple trees were injected with solution containing potassium phosphate (0.25 percent) and urea (0.25 percent) at the rate of 0.033 to 0.167 pound per tree or 10 to 50 pounds per acre. Attacks by the apple leafhopper and red spider were markedly less severe on the injected trees than on the control. Fertilizer was applied in a single hole (0.25 in.diameter) drilled diametrically through the main stem, and all branches of the tree were uniformly affected.

Roach, W. A.

The diagnosis and cure of chlorosis in a peach tree. Ibid., 139-41.

Lime-induced chlorosis in a peach tree was cured by injections of 0.05 percent solutions of ferric chloride through one quarter inch holes bored diametrically through the main stem. This treatment had no ill effect on the tree.

Roach, W. A. (68)

1935. Leaf injection. East Malling Research Sta. 23d Ann. Rept., pp.134-136.

Various solutions were used in leaf-injection work. They included zinc sulphate, manganese sulphate, iron tartrate, and copper sulphate.

A tree was cured of chlorosis by injecting a solution of ferric tartrate through a hole passing through its main stem.

Roth, C. (69)

1896. Eine Methode der künstlichen Baumer-nährung. Chem. Ztg. 20:344-345, illus.

The author described a method and apparatus for injecting trees. He used solutions of potassium nitrate, calcium sulphate, calcium orthophosphate, sodium chloride, magnesium sulphate, and ferric chloride. He also used antiseptics such as salicylic acid and solutions such as sugar, etc., with beneficial results to the trees.

Rumbold, C. (70)

1913. Report of the physiologist. Report of the Pennsylvania Chestnut Tree Blight Commission. Harrisburg, July 1 to December 31, 1912, pp. 45-47, illus.

Illustrations are given of sections of trees injected with various chemicals.

Rumbold, C. (71)

1915. Methods of injecting trees. Phytopathology 5:225-229, illus.

A discussion of the various methods used by the author for the injection of liquids in chestnut trees in a study of the chestnut blight.

Rumbold, C. (72)

1920. Effect on chestnuts of substances injected into their trunks. Amer. Jour. Bot. 7:45-56, illus.

The effects of a large number of chemicals injected into chestnut trees is described. (See ibid., pp.1-20.)

Rumbold, C. T. (73)

1920. Giving medicine to trees. Jour. Forestry 26:359-362.

A study of the injection of chemicals into chestnut trees as cure for the blight is described. Fifty-six organic and inorganic substances in solution were injected (the compounds are not mentioned). Lithium hydroxide and lithium carbonate seemed to have a temporary inhibiting effect.

Rumbold, C. T. (74)

1920. The injection of chemicals into chestnut trees. Amer. Jour. Bot. 7:1-20, illus., bibliog.

Injections of chemicals were made into chestnut trees for the purpose of controlling the blight. The substances injected were copper sulphate, copper chloride, zinc carbonate, mercuric chloride,

potassium chromate, potassium bichromate, barium chloride, colloidal cuprous hydroxide, colloidal metallic silver, potassium carbonate, potassium hydroxide, potassium sulphate, ammonium carbonate, ammonium chloride, ammonium hydroxide, ammonium sulphate, sodium carbonate, sodium chloride, sodium hydroxide, lithium carbonate, lithium chloride, lithium sulphate, lithium hydroxide, lithium nitrate, methyl alcohol, formalin, acetic acid, formic acid, lactic acid, citric acid, aniline sulphate, phenol, sodium carbolate, "phenol sodique" (carbolic acid NaOH), para nitro phenol, ortho nitro phenol, picric acid, meta cresol, para cresol, thymol, pyrocatechin, pyrogallic acid, phlorglucin, oil of bitter almonds, benzoic acid, salicylic acid, bark extracts, water extract of chestnut tree bark, water extract of chestnut blight canker, methyl green, methylene blue, eosin, congo red, and trypan blue. Solutions of organic compounds went into the trees more readily than solutions of inorganic compounds.

Sachs, Julius von. (75)

1875. Geschichte der Botanik, vom 16 jahrhundert bis 1860. 612 pp., illus. München.

Sachs, J. (76)

1882. Ein Beitrag zur Kentniss der aufsteigenden Saftstroms in transpirirenden Pflanzen. Arb. Bot. Inst. Würzburg 2:148-184.

This was an investigation of the physiological action of chemicals on plants and trees. The author found that substances such as lithium solutions would progress in the stem almost as rapidly as water itself, while solutions which dye the cell walls do not rise nearly so rapidly or so far, since they are largely filtered out.

Sachs, M. A. (77)

1931. Injection treatment of chlorotic citrus trees. Calif. Citrograph 16:250-251.

Powdered ferrous citrate was injected dry into bore holes in trees and these were then sealed over. The treatment gave good results in some cases against chlorosis.

Sanford, F. (78)

1914. An experiment on killing tree scales by poisoning the sap of the tree. Sci.(n.s.) 40:519-520.

Potassium cyanide was considered beneficial to a peach tree infested with the cottony- cushion scale. The material was inserted through a bore hole and the treatment completely eradicated the scale with no bad effects on the tree.

Sanford, F. (79)

1915. In regard to the poisoning of trees by potassium cyanide. Sci. (n.s.) 41:213.

The author reported that a tree that had been injected with potassium cyanide the previous year was examined and found to be uninjured.

Saussure, Nicolas Theodore de. (80)

1840 Recherches chimiques sur la végétation. 327 pp. Paris.

Scherer, C. M. (81)

1927. Tree injections for the control of fungous diseases and insect pests. Phytopathology 17:53.

Chestnuts, birches, and apple trees were injected with chemicals to control chestnut blight, the bronze birch borer, and the European elm scale but without success.

The chestnut trees were injected with acid fuchsin, Bayer compound, brilliant green, ferrous sulphate, gentian violet, lithium carbonate, malachite green, methyl blue, safranin, "Semisan", sodium carbonate, sodium fluoride, "sulphocide", thymol, zinc chloride, and zonite; the birches with arsenic trioxide, "Bayer Compound", "Black-Leaf 40", and strychnine sulphate; the apples with acid fuchsin, gentian violet, and thymol; and the elm with strychnine sulphate.

All results were negative with the exception that the apple trees that were injected with thymol seemed to show a definite resistance to the progress of Bacillus amyloverus.

Shattuck, C. H. (82)

1915. Effect of potassium cyanide in trees. Sci. (n.s.) 41:324.

The author reported that he had used potassium cyanide many times very successfully for killing wood borers in elm and black locust trees and without injury to the trees.

Sheviryev, I. (83)

1895. On impregnating the woody fibers of living trees with coloring solutions. Trudi, Imp. St. Petersburg Obstachestva Yestyestvoispitatyelyei, Botanical Section v. 25, 109 pp., illus.

The author notes the importance of finding a substance that can be introduced into living plants in sufficient quantities to destroy parasites without injuring the plants. A method was discovered by which this could be done. Compounds that are satisfactory will require further investigation.

Shcyrez, Ivan (Shevyrev J., Schewirew or Chewyreuv). (84)

1894. Extraradicate nutrition of diseased trees with the aim of curing them and destroying their parasites.

(Records of the Botanical Div. St. Petersburg Imperial Society of Naturalists. Conference of February 16, 1894. - Supplement to "Extradicate nutrition of diseased tree." 1. Reprint from the Agricultural Gazette Nos. 3,4,5, and 6, St. Petersburg. Translation by U. S. Dept. Agr. Forest Serv.)

Experiments are reported on injections of living trees with stains to prove that substances foreign to trees could be injected with safety. The experiments were made for the purpose of destroying insects that burrow beneath the bark of trees. It was suggested that fungous diseases could be controlled by the same method.

Simon, J. A. (85)

1906. Recherches sur l'alimentation artificielle des plantes. Jour. Soc. Nat. Hort. France (ser. 4) 7:674-678. illus.

Apple and peach trees, grapevines, and potatoes were injected with water solutions of purin and potassium nitrate and nutrient solutions. Copper sulphate injected into grapevines was at first injurious but later the vines produced new leaves free from fungi.

Stover, N. M., and Hopkins, B. S. (86)

1927. Fungicidal and bactericidal action of selenium and tellurium compounds Indus. Eng. Chem. 19:510-513.

No fungicidal action of solutions of sodium selenite, sodium tellurite, potassium selenite, potassium tellurite, and titanium acid tartrate in concentration of 0.05 to 0.0005 M was observed on the fungus which causes chestnut blight. Selenious acid in concentration 0.10 M to 0.04 M did not control apple blotch. Solutions of selenious acid will enter the circulatory system of pear and chestnut trees. A successful method of tree injection is described in detail.

Strasburger, Edward. (87)

1891. Histologische betrage, Heft 3. Ueber den Bau und die Verrichtungen der Leitungsbahnen in den Pflanzen. 1,000 pp., illus. (See pp.551, 555, 556.) Jena.

The physiological action of chemicals on plants is described.

Surface, H. A. (88)

1914. Cyanide of potassium in trees. Sci. (n.s.) 40:852-854.

The author reported serious injury to orchards in Pennsylvania by injections of potassium cyanide, ferrous sulphate, potassium chloride, and other salts for curing fruit trees of insect troubles and other diseases. Many of the trees were killed by injections through bore holes.

Thomas, E. E., and Haas, A. R. C. (89)

1928. Injection method as a means of improving chlorotic orange trees. Bot. Gaz. 86:355-362, bibliog.

Injections were made using iron sulphate and iron tartrate, with good results.

Thomas, L. A., and Roach, W. A. (90)

1934. Injections of fruit trees, preliminary experiments with artificial manures. Jour. Pomol. 12:151-156. illus. bibliog.

Small trees were injected with various solutions through a single hole in the main stem. A description and an illustration of the apparatus are given. Solutions used contained potassium nitrate, potassium phosphate, potassium sulphate, potassium chloride, sodium nitrate, sodium sulphate, magnesium nitrate, magnesium sulphate, magnesium chloride, calcium nitrate, calcium chloride, ammonium phosphate, ammonium nitrate, ammonium sulphate, ammonium chloride, and urea.

University of California Agricultural Experiment Station. (91)

1924. Plant nutrition. Calif. Agr. Expt. Sta. Rpt. 1924, pp. 48-49.

A new method of injecting chemicals into trees offers great possibilities in overcoming chlorosis and also in protecting trees against certain plant diseases.

Valder, G. (92)

1902. The eradication of prickly pears. Agr. Gaz. N.S. Wales. 13:59-62, illus.

The author reported that solutions of sodium arsenite were very effective in killing the tops of prickly pear. He also injected copper sulphate, sulphuric acid, carbolic acid, potassium oxalate, potassium ferrocyanide, sodium arsenite, caustic potash, iron sulphate, and sodium chloride into the lower portions of plants without much success.

Wallace, T. (93)

1935. Investigations on chlorosis of fruit trees; V, control of lime-induced chlorosis by injection of iron salts. Jour. Pomology 13:54-67, bibliog.

The experiments consisted of the injection of various amounts of powdered citrate of iron, either ferrous or ferric, into the wood of the trunk or branches of affected trees. The results indicate that the method of dry salt injection is of considerable value as a means of controlling lime-induced chlorosis.

Wheeler, G. S. (94)

1927. New dye process may solve the eastern hardwood problem. Jour. Forestry 25:357-61.(Also in Aust. Forestry Jour. 10:124-127.)

A process is described for injecting dyes into hardwood trees for the purpose of coloring the wood. Aniline dyes are used. A system of connecting holes are bored into the trees and then connected by tubing with a reservoir of solution.

Wieler, A. (95)

1888. Aufnahme von Methylenblau und Fuchsin durch die Wurzeln legender Pflanzen. Juhrb. Wiss. Bot. 19:119-137, illus.

The physiological action of chemicals on plants is discussed.

Wislicenus, H. (96)

1937. Zur Technik de Lebendurchtränkung (Vergiftung) von Bäumen mit Konservierungsmitteln. Tropenpflanzer 40:432-444, illus.

The theory of tree impregnation and the manner of applying preservatives through trunk borings is described and illustrated.

Young, L. C., and Bailey, C. F. (97)

1936. Progress report on the investigations of corky core on apples. Sci. Agr. 17:115-127. Bibliog. (Summary in French).

Injections of wet and dry materials were made through bore holes in limbs of trees. The materials included magnesium sulphate, zinc sulphate, boric acid, and borax.

PATENTS

Behr, Fritz, von (98)

Impregnating process for dyeing or preserving wood. U. S. Patent 1,740,484, Appl. June 2, 1926. Issued December 24, 1929.

A process for injection of dyes and preservatives into the roots and stems of living trees. Aniline dyes or combinations of aniline dyes distributed in a solution containing about equal parts (by weight) of alum, borax, zinc chloride, sodium perborate, and acetic acid are claimed.

Dahlberg, Arnold V. (99)

Method of fertilizing trees and shrubs.
U. S. Patent 2,044,003, Appl. February 3, 1936. Issued June 16, 1936.

A method of feeding fruit trees by introducing nutrient solutions into the tree by injection, independently of the natural root system of the tree is claimed.

Derby, Ira H., and Cislak, Francis Edward. (100)

Process for treating wood.
U. S. Patent 1,995,499. Appl. September 17, 1931. Issued March 26, 1935.

Relates to a preservative treatment for wood consisting of a preliminary treatment with a gas such as sulphur dioxide and then preservative liquids such as creosote oil.

Gardner, Levi S. (101)

Art of coloring wood.
U. S. Patent 952,245, Appl. December 8, 1908. Issued March 15, 1910.

The injection of living trees with coloring matter and preservatives is described. Coloring matters that may be used include copper sulphate, copperas, nitric acid, sulphuric acid, potassium cyanide, liquid dyes, silver nitrate, and coal-tar colors. Substantially the saw kerf method is described.

Habegger, Hans. (102)

Method of impregnation for preserving wood by treatment of living standing trees.
U. S. Patent 1,927,776. Appl. August 18, 1932. Issued September 19, 1933.

Living trees are injected through bore holes with a solution of sodium nitro-chlorophenol.

Hartman, Ernest, F., and Whitmore, Willet F. (103)

Composition for impregnating wood and other cellulose materials.
U. S. Patent 1,994,073. Appl. July 12, 1930. Issued March 12, 1935.

The treating solution may contain zinc chloride and other water-soluble zinc salts, copper sulphate and other water-soluble copper salts, ammonium chloride, sodium fluoride, ammonium sulphate, mono ammonium phosphate, di ammonium phosphate, boric acid, sodium chromate, and sodium borate.

Laffin, James E. (104)

Method of treating trees.
U. S. Patent 1,682,760. Appl. August 26, 1925. Issued September 4, 1928.

A method of dyeing wood by injecting dye solutions into living trees is described.

Lipman, Charles, B., and Gordon, Aaron. (105)

Method of impregnating wood with substances toxic to animal and bacterial life and fungous growths.
U. S. Patent 1,693,930. Appl. September 9, 1926. Issued December 4, 1928.

The injection of chemicals into living trees is described. The materials mentioned include copper arsenate, copper sulphate, copper chloride, copper nitrate, or any other copper salt. Soluble salts of mercury, zinc, lead, and creosote or the soluble and toxic constituents thereof. Any soluble chemical compound or combination of compounds which is toxic to wood-boring and wood-destroying organisms is claimed.

Lipman, Charles, B., and Gordon, Aaron. (106)

Impregnating living tree with preservatives. U. S. Patent 1,805,550. Appl. November 5, 1927. Issued May 19, 1929.

A toxic substance such as an ammoniacal solution of copper hydroxide capable of distribution by the sap and serving as a parasiticide and fungicide is injected into living trees and permitted to circulate with the sap, and there may be simultaneously injected another material which serves to reduce and fix the toxic substance in the cellular and fibrous structure.

Preston, Charles F. (107)

Process of treating wood.
U. S. Patent 2,111,494. Appl. January 24, 1936. Issued March 15,1938.

A process for treating wood, especially soft wood, whereby the surface is impregnated with a stain which is fixed more firmly than in the usual procedure is claimed.

Rankin, Wm. Howard. (108)

Apparatus for introducing substances into trees.
U. S. Patent 1,718,195. Appl. June 15, 1926. Issued June 18, 1929.

Mechanical apparatus for tree injections is described.

Reimann, Otto. (109)

Method of dyeing or impregnating the wood in living trees.
U. S. Patent 1,500,469. Appl. August 16, 1921. Issued July 8, 1924.

A method of dyeing wood by injecting dye solutions into living trees is claimed.

Reimann, Otto

Apparatus for preparing living trees for coloring the wood.
U. S. Patent 1,538,745. Appl. March 21, 1923. Issued May 19, 1925.

Mechanical apparatus is described.

Reimann, Otto. (111)

Method for removing the sap from felled trunks and for impregnating, coloring or dyeing the same.
U. S. Patent 1,727,251. Appl. November 17, 1927. Issued September 3, 1929.

A method of impregnating or injecting chemicals into felled trees is described.

Renner, Herbert (112)

Process for dyeing wood.
U. S. Patent 1,570,575. Appl. October 26, 1923. Issued January 19, 1926.

A process for dyeing wood by injecting chemicals into living trees is described. "One or more of a large series of coloring metal compounds held in solution or suspension in water such as molybdenum, copper, antimony, tin, iron, manganese, chromium, nickel, uranium, cobalt, or the like may be used. Combined therewith are volatile or unstable organic or inorganic chemicals in solution or suspension such as ammonia, formic acid, or the like." Either acids, bases, or salts or compounds for oxidation or reduction may be used.

Renner, Herbert. (113)

Impregnation of wood and the like.
U. S. Patent 1,683,488. Appl. February 7, 1925. Issued September 4, 1928.

A method of dyeing wood by injecting dye solutions into living trees is described.

Renner, Herbert. (114)

Art of foresting and dyeing standing living trees.

U. S. Patent 1,727,939. Appl. March 7, 1924. Issued September 10, 1929.

A method of dyeing wood by injections of dyes into living trees is claimed.

Schmittutz, Carl (115)

Method of impregnating wood.

U. S. Patent 1,973,394. Appl. July 26, 1933. Issued September 11, 1934.

A water-soluble impregnating substance in pastry form is applied to the smooth, bared portion of the stem. Impregnating materials may be composed of zinc fluosilicate, potassium fluoride, or other myocide salt of known composition.

Yates, Alvin. (116)

Composition for treating diseased trees.

U. S. Patent 2,017,269. Appl. March 20, 1935. Issued October 15, 1935.

A treatment is described for injection of chemicals into fruit trees, pear, apple, quince, and others. Materials used were turpentine and oil of pine tar.

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